JOINT STRIKE FIGHTER

Sharing M&S Between Gov't and Industry

JSF Collaborative Environments

3rd NDIA SBA Conference, Springfield, VA - 17 May 01

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The Next Generation Strike Fighter

JSF PROGRAM OVERVIEW

MS&A CHALLENGES & SOLUTIONS

LESSONS LEARNED & CONCLUSIONS

VISION

BE THE MODEL ACQUISITION PROGRAM FOR JOINT SERVICE AND INTERNATIONAL COOPERATION

DEVELOP AND PRODUCE AN AFFORDABLE NEXT GENERATION STRIKE FIGHTER WEAPON SYSTEM AND SUSTAIN IT WORLDWIDE

SERVICE NEEDS

- **USN (480)**
  - Multi-role, stealthy strike fighter to complement the F/A-18E/F
- **USAF (1763)**
  - Multi-role (primary air-to-ground) fighter to replace the F-16 and A-10 and to complement the F-22
- **USMC (609)**
  - Multi-role, short takeoff, vertical landing strike fighter to replace the AV-8B and F/A-18C/D
- **UK Royal Navy and Royal Air Force (150)**
  - Supersonic STOVL replacement for the Sea Harrier and GR-7






JSF CONCEPT DEMONSTRATION PHASE

JSF Weapon System Analysis & Integration Team

FY 94 | FY 95 | FY 96 | FY 97 | FY 98 | FY 99 | FY 00

Requirements Evolution/Cost as an Independent Variable (C

Initial Req. Document | JIRD II | JIRD III | Draft JORD | JORD Signed | EMD START

Concept Exploration | Concept Development | Concept Demonstration & Flying Demonstrators

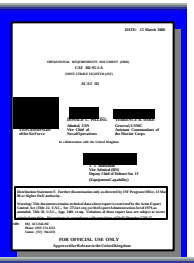
1st Flight | MS II

RFP | PROP | SS | Concepts X-32 & X-35 | CFI | PROP | SS

High-Lev Tech & Demos

Structures & Materials
Flight Systems
Manufacturing & Production
Mission Systems
Supportability
Propulsion

- Joint ORD Validated by JROC Mar 2000



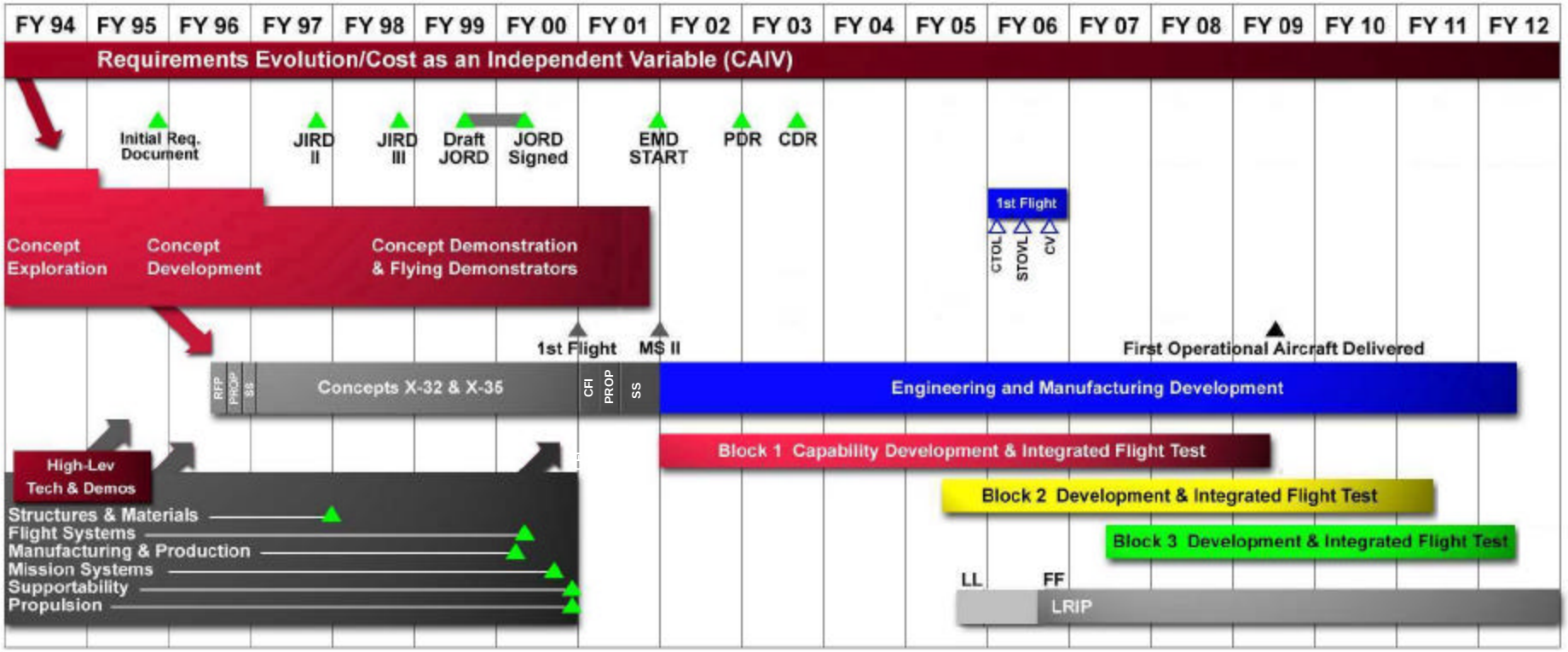
- CDP Flight Testing On-Going

- EMD CFI Released
- Source Selection On-Going

- Successfully Leveraged Technologies

JSF PROGRAM SCHEDULE

JSF Weapon System Analysis & Integration Team



BOEING X-32A/C (USAF / USN)

First Flight on 18 Sep 2000

SIGNIFICANT ACCOMPLISHMENTS (CTOL):

- **Supersonic on 21 Dec 2000**
- **Aero Performance**
- **Completed CTOL Flying Qualities**
- **Afterburner Ignition Completed**
- **6 Pilots (Boeing, USAF, USMC, USN, RN)**
- **Weapons Bay Acoustic Testing Completed**
- **Flew to Palmdale, CA for Storage**

SIGNIFICANT ACCOMPLISHMENTS (CV):

- **All Field Carrier Landing Practice (FCLP) Completed**
- **Auto Throttle Flying Qualities Successfully Evaluated**
- **Completed CV Flying Performance and Qualities**

BOEING X-32B (USMC / UK)

FLIGHT TEST:

- **First Flight (CTOL) Completed on 29 Mar 2001**
- **Arrived at Edwards AFB to Begin 10-15 Hours of Basic Airworthiness and STOVL Checkout Flights**

SIGNIFICANT ACCOMPLISHMENTS:

• Conventional Engine Runs	20 Dec 2000
• STOVL Engine Runs	6 Jan 2001
• Low and Medium Speed Taxi	8 Jan 2001
• AMT Engine Test Complete	8 Jan 2001
• Ground School Complete	24 Jan 2001
• First Flight Readiness Review (FFRR) Complete	6-7 Feb 2001
• Engine Flight Clearance Review	27 Feb-1 Mar 2001
• STOVL Max Power Untethered Engine Test	8 Mar 2001

LOCKHEED MARTIN X-35A/B (USMC / USAF)

CTOL First Flight on 24 Oct 2000
STOVL First Flight Planned Summer 2001

SIGNIFICANT ACCOMPLISHMENTS (CTOL):

- **Aero Performance, Flight Handling Qualities, Supersonic Flight**
- **Qualified for KC-135 Inflight Refueling**
- **6 Pilots (LM, USAF, USMC, RAF, BAE)**
- **All CTOL Objectives Met**
- **Complete Engine Checkout to Include Full Afterburner Employment**

SIGNIFICANT ACCOMPLISHMENTS (STOVL):

- **STOVL Propulsion System (including LiftFan) Successfully Installed Dec 2000**
- **X-35B STOVL Variant Modifications from X-35A CTOL Configuration Complete**
- **X-35B STOVL Propulsion Ground Engine Testing Underway on Pit**
- **Full Installed STOVL Engine/LiftFan Power Demonstrated on Test Pit**

LOCKHEED MARTIN X-35C (USN)

FLIGHT TEST:

- **CV First Flight on 16 Dec 2000**
- **73 Flights, 58 Hours**
- **CV Flight Test Completed 10 Mar 2001**

SIGNIFICANT ACCOMPLISHMENTS:

- **Field Carrier Landing Practices (FCLP)**
- **Aero Performance**
- **Flight Handling Qualities**
- **8 Pilots (LM, USN, USAF, USMC, UK, BAE)**
- **Engine Checkout to Include Full Afterburner Employment**
- **Qualified for KC-10/KC-135 Inflight Refueling**
- **Supersonic Flight**
- **Transcontinental Ferry Flight to Naval Air Station, Patuxent River**

JSF PROGRAM OVERVIEW

MS&A CHALLENGES & SOLUTIONS

LESSONS LEARNED & CONCLUSIONS

MS&A Challenges & Solutions

A. MS&A customers and their information needs

B. The Joint Operational Requirements Document (ORD)

C. Shared responsibilities between Gov't & Industry

D. A standard Suite of Models & Simulations (SoM&S)

E. Authoritative representations within the SoM&S

F. The JSF-specific Joint Synthetic Battlespace

G. Configuration Management & Joint VV&A

H. Buy-in from the Test Community

MS&A Challenges & Solutions

A. Determining MS&A customers and information needs

Solution: Realizing that MS&A is a support function, use the Systems Engineering process to identify customers and their info needs.

- **Contractors** - Support detailed design and manufacturing decisions
- **T&E community** - Satisfaction of JSF spec and JORD requirements (DT/OT)
- **Warfighters** - Training and CONOPS development / refinement
- **Logisticians** - Supportability issue analysis
- **Mission Planners** - Mission management system design and evaluation
- **Services and CINCs** - Advanced Warfighting Experiments (AWEs) & Joint Force Experiments (JFXs)
- **OSD, Joint Staff, Higher HQ** - QDR, budget & force structure issues
- **Congress** - Program support, issue resolution
- **Coalition Partners** - Issue resolution, assessments, program support, etc. (most of above)

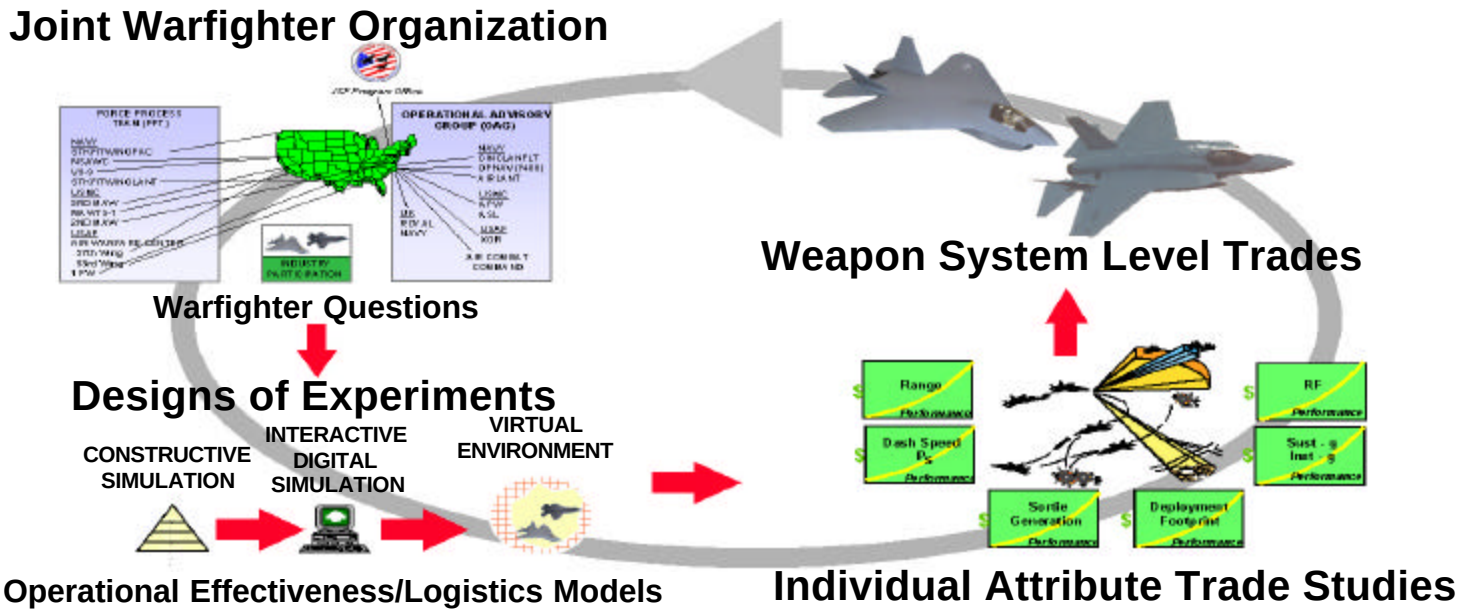
MS&A Challenges & Solutions

B. Defining the Joint Operational Requirements Doc (ORD)

Solution:

- ★ Early & continuous warfighter involvement
- ★ Cost & Operational Performance Trades with Industry
- ★ Use of Man-In-The-Loop (MITL) Simulation
- ★ Linkage of MITL to Constructive Simulation

COST & OPERATIONAL PERFORMANCE TRADES (COPT) PROCESS
ESTABLISHED IN 1994



MS&A Challenges & Solutions

C. *Establishing shared Responsibility between Gov't & Industry*

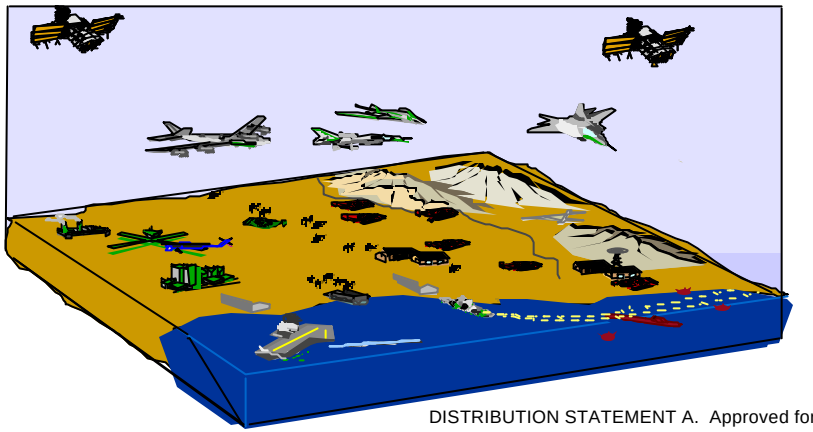
Solution: Clearly define the Government & Industry responsibilities

★ ***EMD Contractor provides the Distributed Product Description (DPD) of their Weapon System***

- Includes data, algorithms, and/or source code
- Describes the operational performance, logistical characteristics, and cost
- Spans the engineering, engagement, mission, and campaign levels

★ ***Government provides the simulation environment in which the DPD-based JSF will operate***

- Threat systems, Friendly systems, logistics resources and infrastructure, Blue & Red C4I, multi-spectral databases, terrain & atmosphere representations



Government and Industry will form a closer M&S partnership than ever before!

MS&A Challenges & Solutions

D. Working from a standard Suite of Models & Simulations

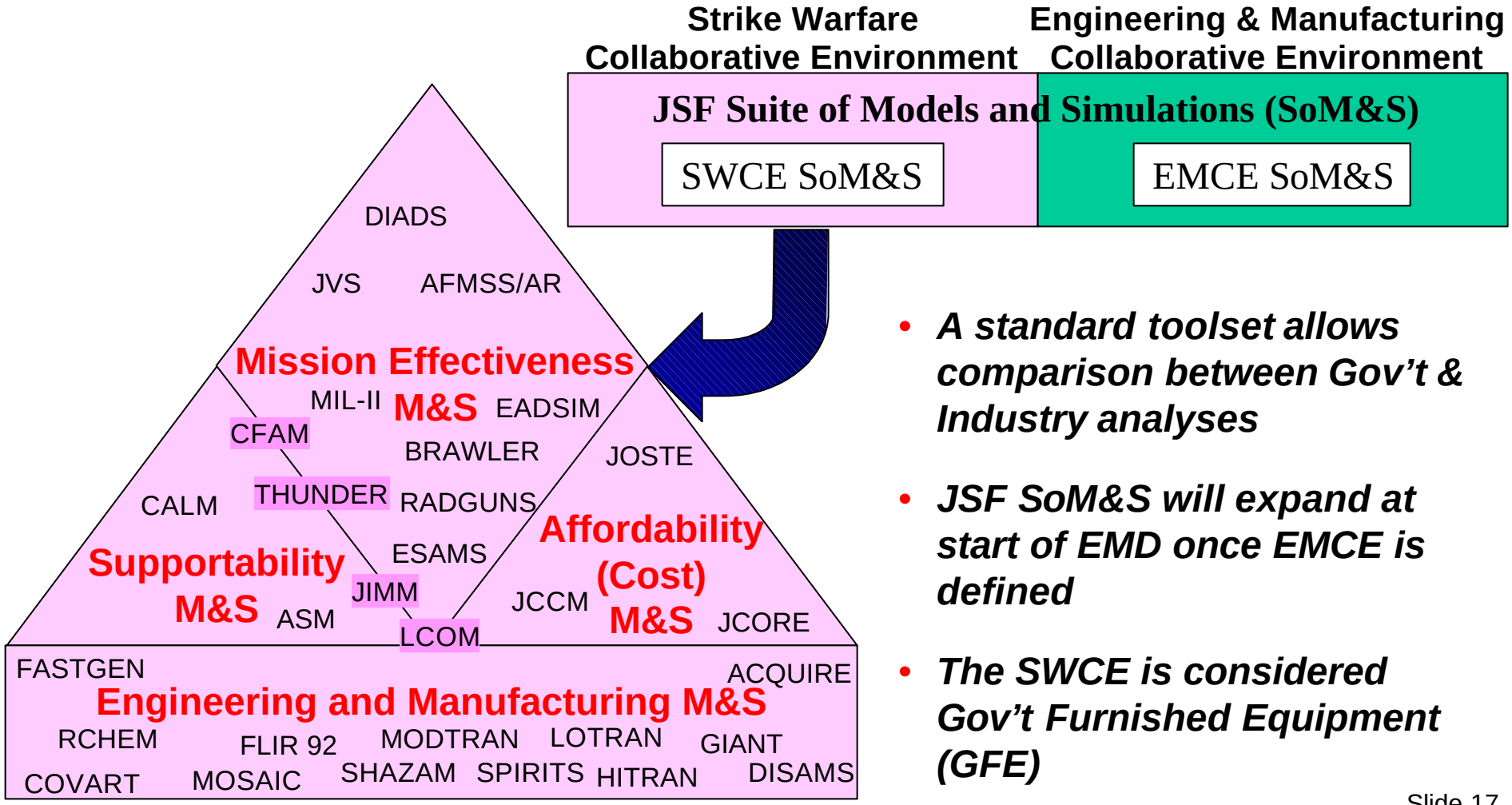
Solution (Part 1): Identify the key areas of collaboration and analysis between Government & Industry...

- **Mission Effectiveness Analysis**
  - Evaluation of effectiveness of JSF to perform its total set of missions
  - Includes performance-oriented simulations primarily at the mission level, but also at the campaign and engagement levels
- **Supportability Analysis**
  - Supportability requirements and capabilities throughout the life cycle
- **Cost Analysis**
  - Determining total ownership cost (TOC)
- **Engineering and Manufacturing Analysis**
  - Engineering and manufacturing by the Weapon System Contractor
  - Includes requirements management and traceability
  - Direct linkage to design and development tools, data products, and analysis of engineering and manufacturing processes

MS&A Challenges & Solutions

D. Working from a standard Suite of Models & Simulations

Solution (Part 2): … Choose a toolset to meet the collaboration needs.

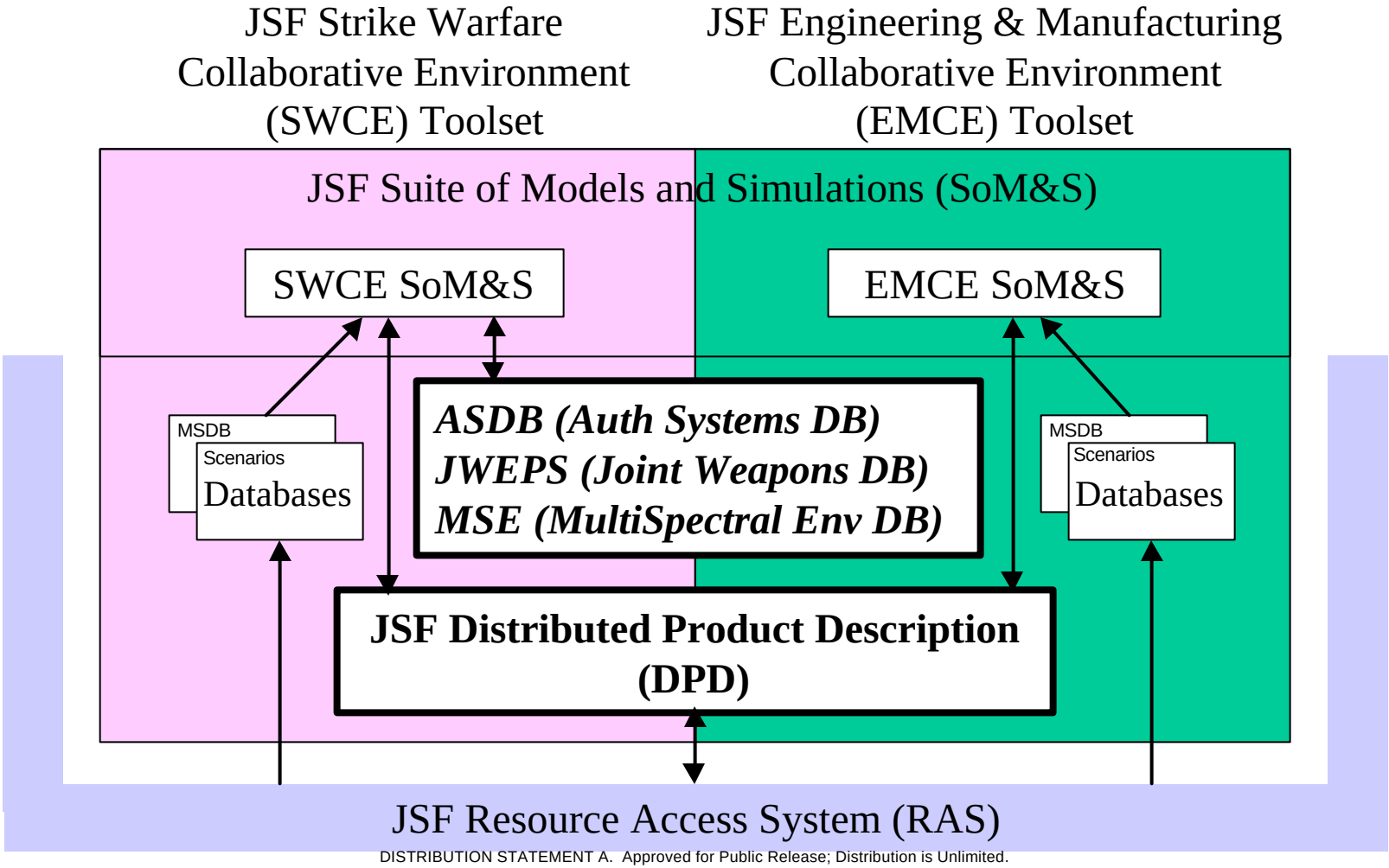


- ***A standard toolset allows comparison between Gov't & Industry analyses***
- ***JSF SoM&S will expand at start of EMD once EMCE is defined***
- ***The SWCE is considered Gov't Furnished Equipment (GFE)***

MS&A Challenges & Solutions

E. Authoritative Representations of Systems within the SoM&S

Solution: Establish a standard set of Modeling Information Sources databases which will feed the Suite of Models and Simulations



MS&A Challenges & Solutions

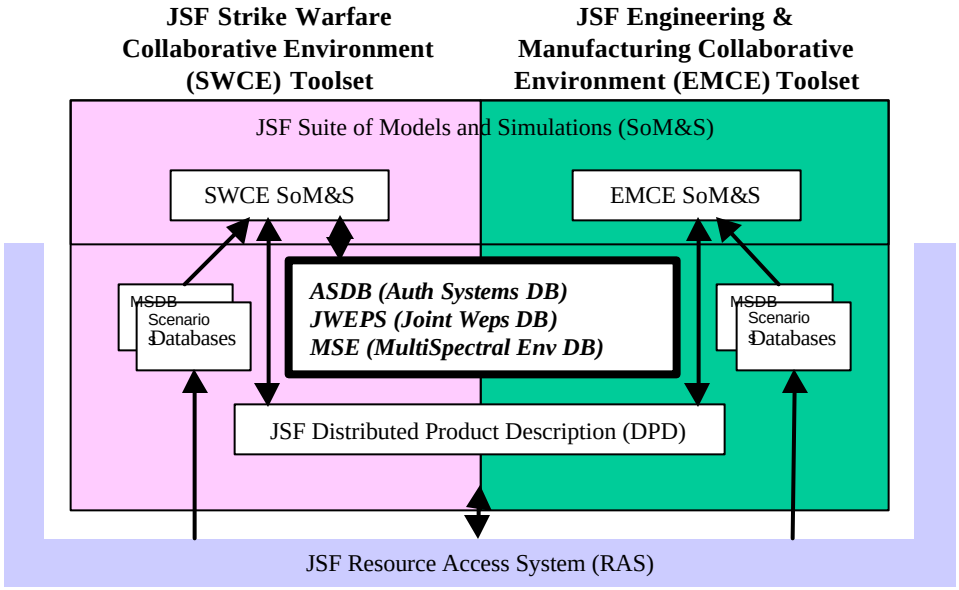
F. Understanding the JSF-specific Joint Synthetic Battlespace

Solution: Realize there will be many facets to the JSB(AF)!

- **Strike Warfare Collaborative Environment (SWCE) toolset +**
  Engineering & Manufacturing Coll Environment (EMCE) toolset +
  Distributed Product Description (DPD) +
  Authoritative Modeling Information Sources =

★ **A JSB suitable for JSF design and test purposes**

(will adhere to best available DoD and commercial standards)
(will be available for all programs to leverage as they choose)



MS&A Challenges & Solutions

G. Performing Configuration Management & Joint VV&A

Solution: Establish mutually agreed upon processes for model and database updates, configuration control, and accreditation.

Configuration Management (CM):

- JSF has an established CM Process -- Industry full members of the Configuration Review Board and Configuration Control Board
- Industry full voting members of JSF Data/Model Improvement Program (D/MIP)

Joint VV&A:

- Accreditation is the responsibility of the user of the data (either JPO, Industry, or a combined JPO/Industry team)
- Several on-going efforts designed to help facilitate accreditation:
  - Concept Demonstration Phase (CDP)
  - Joint Accreditation Support Activity (JASA)
  - Independent Environment Validation (IEV)
  - Independent VSWE Accreditation Team (IVAT)
  - Standardizing database formats (to assist in data pedigree)

MS&A Challenges & Solutions

H. Maintaining Test Community Buy-In

Solution:

- **Strive for continued logical growth of M&S use for Developmental Test (DT) (e.g., component, integration, and system-level test).**
- **The Operational Test (OT) community is involved earlier than any other aircraft program in history.**

Specific examples:

- **AFOTEC and COMOPTEVFOR are full members of the MS&A IPT**
- **Both Gov't and Industry have already started addressing Hardware-In-The-Loop (HITL) integration issues to support DT**
- **The OT community has the lead on developing a Nellis Test & Training Range (NTTR) scenario, as well as the Independent Environment Validation (IEV) effort.**
- **JSF JPO leadership has adopted a "Zero Based Flight Test" philosophy (all flight test hours must be justified).**
  - M&S will not replace flight test, but focus it and support extrapolation
  - Flight test will be used to validate predicted M&S results

JSF PROGRAM OVERVIEW

MS&A CHALLENGES & SOLUTIONS

LESSONS LEARNED & CONCLUSIONS

LESSONS LEARNED SUMMARY

- **Maintain early & continuous involvement of the Warfighter**
  - Necessary for requirements definition and CONOPS refinement
  - Man-in-the-loop (MITL) simulation was vital for proper understanding
- **Link the virtual sims (MITL and HITL) with constructive sims**
  - MITL is a strong complement to constructive simulation
  - Gains acceptance within both warfighter and analytical communities
- **Establish a standard Suite of Models & Simulations across the program (between Gov't and Industry) with:**
  - Clearly defined responsibilities for Configuration Management and model / database improvements
  - Authoritative representations of systems within the SoM&S
  - Joint VV&A processes
- **As with the Warfighter, garner early and continuous involvement of the OT community as full members of appropriate IPTs**

JSF M&S SUPPORT PLAN (MSSP)

- **Describes the JSF SBA Vision & Philosophy**
- **Documents M&S support to development, test, fielding, and sustainment of the JSF Air System**
- **Outlines Government and Industry responsibilities**
- **Describes Configuration Management processes**
- **Complies with:**
  - AFI 16-1002 M&S Support to Acquisition
  - DoD 5000.59 DoD M&S Management
  - DoD 5000.59P M&S Master Plan
  - DoD 5000.61 Verification, Validation & Accreditation (VV&A)
- **Required for Milestone II (i.e., entry into EMD)**
- **EMD Contractual Reference Document**
- **Classified "For Official Use Only"**
  - Not available to the general public at this time.

CONCLUSIONS

- **JSF MS&A efforts are focused on meeting the needs of the program throughout all phases, while simultaneously fostering reuse throughout the defense community.**
- **JSF is 1st program to make many SBA concepts a reality**
  - Tightly integrated Government/Industry team
  - Collaborative Environments (SWCE and EMCE)
  - Distributed Product Description (DPD)
  - Authoritative Modeling Information Sources
- ***"The M&S Support Plan IS the EMD program."***

JSF MS&A -- This is NOT business as usual !!!

JOINT STRIKE FIGHTER

The Next Generation Strike Fighter

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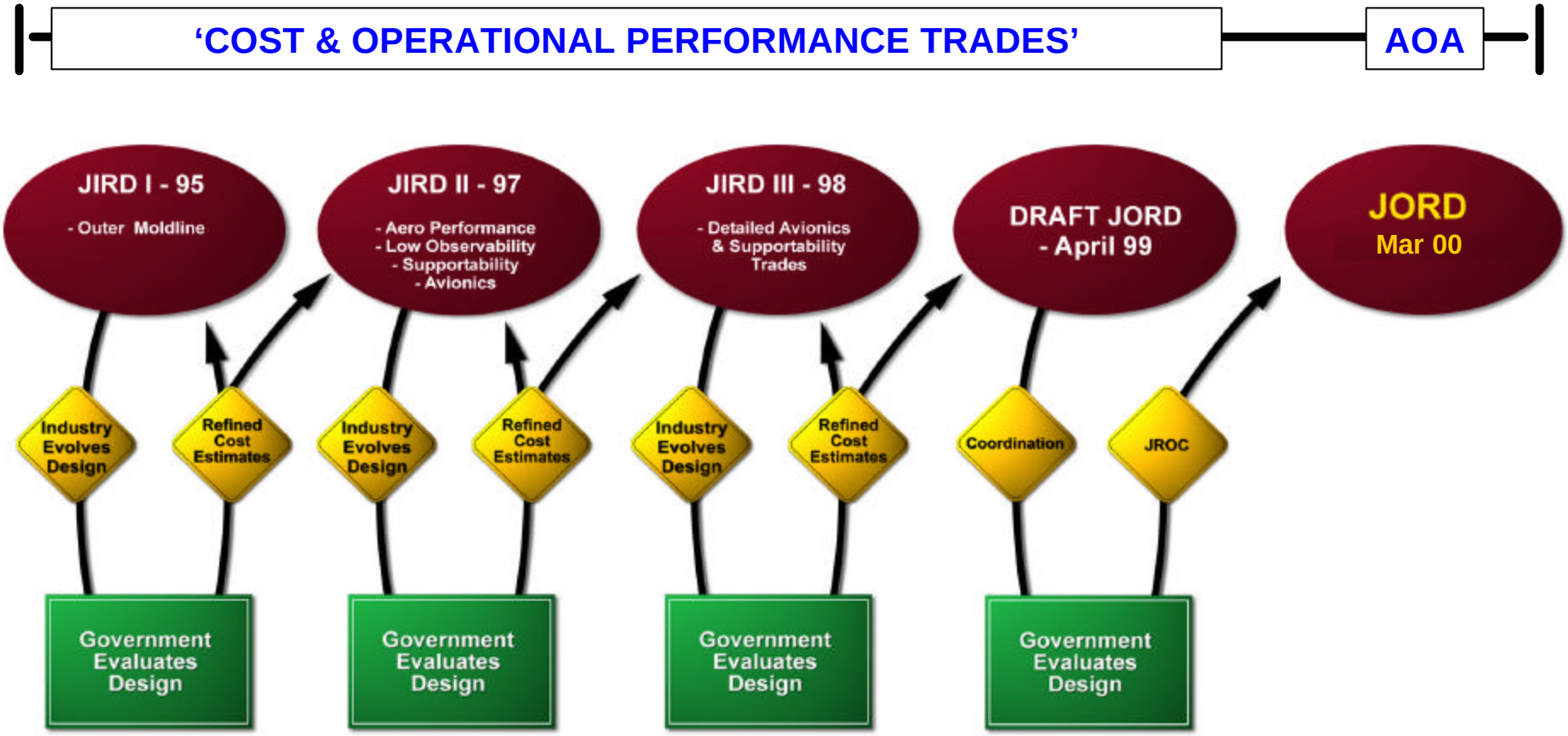
BACKUP SLIDES

ROADMAP TO THE JORD



Feedback & Reiteration Loop Throughout Process

FIVE YEAR EFFORT!!!

SIMULATION BASED ACQUISITION (SBA) vs. MODELING & SIMULATION

Simply using M&S [1] SBA!!!

SBA is a LEADERSHIP issue:

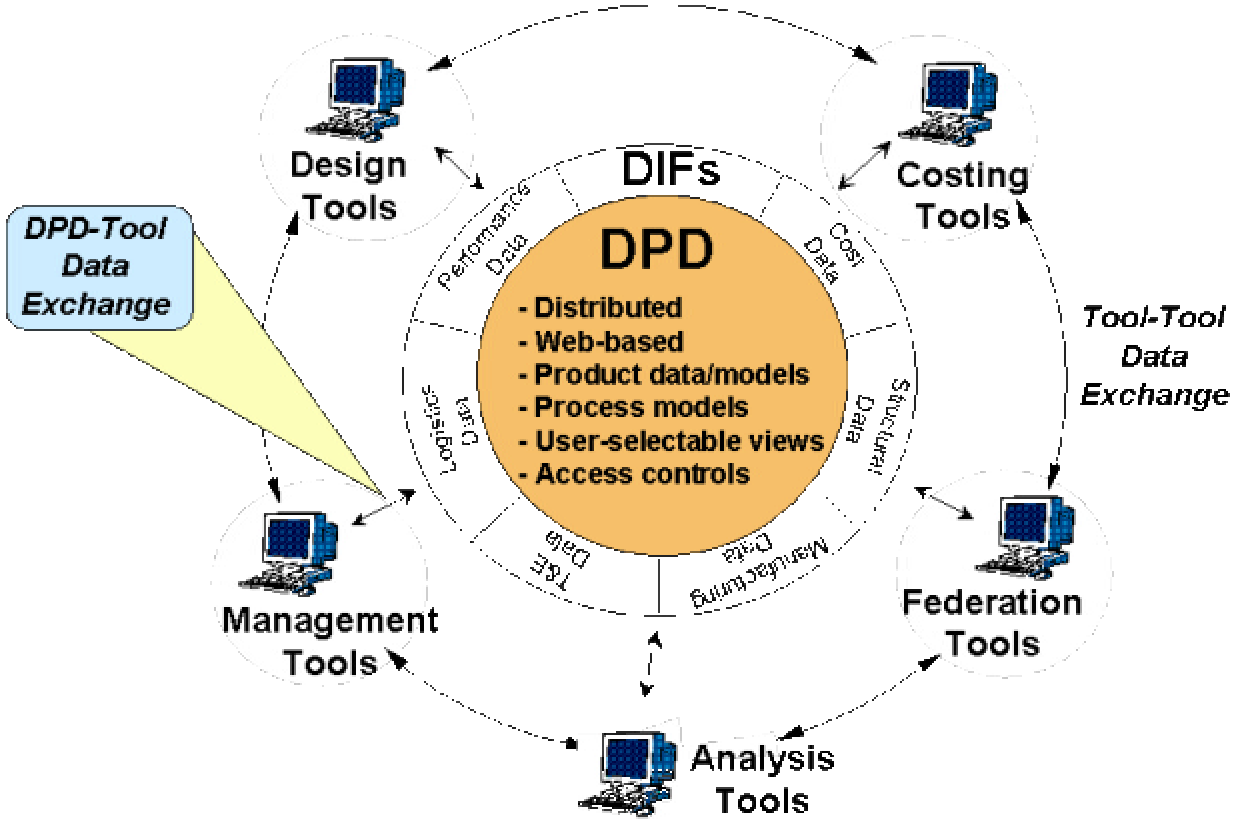
- **Requires a change in mindset of senior leadership, management, and technical experts**
- **No magic collection of models or databases; the key is to use the same ones throughout the program**
- **The SBA philosophy of integrated M&S use must permeate all aspects of a program**

JSF views SBA as integral to smarter Systems Engineering -- It is Evolutionary, not revolutionary

Components of the JSF SWCE Suite of Models and Simulations

ACQUIRE	
AFMSS/AR	**Air Force Mission Support System / Auto-Router**
ASM	**Aircraft Sustainability Model**
Brawler	
CALM	**Consolidated Air Load Manifest**
CFAM	**Combat Forces Assessment Model**
COVART	**Computational Vulnerability and Repair Time**
DIADS	**Digital Integrated Air Defense System**
DISAMS	
EADSIM	**Extended Air Defense Simulation**
ESAMS	**Enhanced Surface-to-Air Missile Simulation**
FASTGEN	**Fast Shotline Generator**
FLIR 92	
GIANT	**GPS Interference and Navigation Tool**
HITRAN	
JCCM	**Joint Common Cost Model**
JCORE	**Joint Services Cost Oriented Resources Estimating Model**
JIMM	**Joint Interim Mission Model**
JOSTE	**JSF Operating and Support Technologies Evaluation Model**
JVS	**JSF Virtual Simulator**
LCOM	**Logistics Composite Model**
LOTRAN	
MIL AASPEM-II	**Man-in-the-Loop Air-to-Air System Performance Evaluation Model**
MODTRAN	
MOSAIC	**Modeling system for the Advanced Investigation of Countermeasures**
RADGUNS	**Radar-Directed Gun Simulation**
RCHEM	**Residual Chemical Hazard Environment Model**
Shazam	
SPIRITS	
Thunder	

DISTRIBUTED PRODUCT DESCRIPTION (DPD)



JSF DPD Goals:

- *Improve timeliness and coherency of JSF information sharing*
- *Improve traceability for JSF representations*
- *Minimize cost in seeking and translating JSF information*
- *Support Configuration Management and archiving of JSF information*

- **The DPD provides the most authoritative information currently available, at various levels of resolution**
- **The DPD describes a product and its development, not its operating environment**

AUTHORITATIVE SYSTEMS DATABASE (ASDB)

Direct Links

Threat Assessments

Intelligence Databases

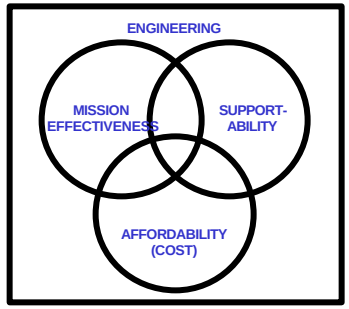
Native Sources View

Authoritative Systems Database

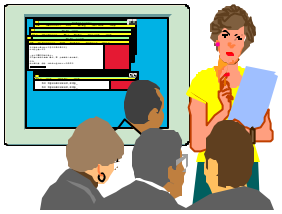
- Red systems
- Blue system
- SoS – C4I
- IADS

Model View

SWCE Toolset



Traceability



JSF Resource Access System (RAS)

EMD INTERNATIONAL PARTICIPATION

- **Cooperative Partner**

  Level I - UK Memorandum of Understanding (MOU) Signed 17 Jan 2001

- **On-Going Negotiations**

  Level II - Italy

  Netherlands

  Turkey

  Level III - Canada

  Denmark

  Norway